

SEARCHES FOR MONOPOLES, SUPERSYMMETRY, TECHNICOLOR, COMPOSITENESS, EXTRA DIMENSIONS, etc.

Magnetic Monopole Searches

Isolated supermassive monopole candidate events have not been confirmed. The most sensitive experiments obtain negative results.

Best cosmic-ray supermassive monopole flux limit:

$$\text{< } 1.0 \times 10^{-15} \text{ cm}^{-2}\text{sr}^{-1}\text{s}^{-1} \quad \text{for } 1.1 \times 10^{-4} < \beta < 0.1$$

Supersymmetric Particle Searches

Limits are based on the Minimal Supersymmetric Standard Model.

Assumptions include: 1) $\tilde{\chi}_1^0$ (or $\tilde{\gamma}$) is lightest supersymmetric particle; 2) R -parity is conserved; 3) With the exception of \tilde{t} and \tilde{b} , all scalar quarks are assumed to be degenerate in mass and $m_{\tilde{q}_R} = m_{\tilde{q}_L}$. 4) Limits for sleptons refer to the $\tilde{\ell}_R$ states. 5) Gaugino mass unification at the GUT scale.

See the Particle Listings for a Note giving details of supersymmetry.

$\tilde{\chi}_i^0$ — neutralinos (mixtures of $\tilde{\gamma}$, \tilde{Z}^0 , and \tilde{H}_i^0)

Mass $m_{\tilde{\chi}_1^0} > 46 \text{ GeV}$, CL = 95%

[all $\tan\beta$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

Mass $m_{\tilde{\chi}_2^0} > 62.4 \text{ GeV}$, CL = 95%

[$1 < \tan\beta < 40$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

Mass $m_{\tilde{\chi}_3^0} > 99.9 \text{ GeV}$, CL = 95%

[$1 < \tan\beta < 40$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

Mass $m_{\tilde{\chi}_4^0} > 116 \text{ GeV}$, CL = 95%

[$1 < \tan\beta < 40$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

$\tilde{\chi}_i^\pm$ — charginos (mixtures of \tilde{W}^\pm and \tilde{H}_i^\pm)

Mass $m_{\tilde{\chi}_1^\pm} > 94$ GeV, CL = 95%

[$\tan\beta < 40$, $m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0} > 3$ GeV, all m_0]

\tilde{e} — scalar electron (selectron)

Mass $m > 73$ GeV, CL = 95% [all $m_{\tilde{e}_R} - m_{\tilde{\chi}_1^0}$]

$\tilde{\mu}$ — scalar muon (smuon)

Mass $m > 94$ GeV, CL = 95%

[$1 \leq \tan\beta \leq 40$, $m_{\tilde{\mu}_R} - m_{\tilde{\chi}_1^0} > 10$ GeV]

$\tilde{\tau}$ — scalar tau (stau)

Mass $m > 81.9$ GeV, CL = 95%

[$m_{\tilde{\tau}_R} - m_{\tilde{\chi}_1^0} > 15$ GeV, all θ_τ]

\tilde{q} — scalar quark (squark)

These limits include the effects of cascade decays, evaluated assuming a fixed value of the parameters μ and $\tan\beta$. The limits are weakly sensitive to these parameters over much of parameter space. Limits assume GUT relations between gaugino masses and the gauge coupling.

Mass $m > 379$ GeV, CL = 95% [$\tan\beta = 2$, $\mu < 0$, $A = 0$]

\tilde{b} — scalar bottom (sbottom)

Mass $m > 89$ GeV, CL = 95% [$m_{\tilde{b}_1} - m_{\tilde{\chi}_1^0} > 8$ GeV, all θ_b]

\tilde{t} — scalar top (stop)

Mass $m > 95.7$ GeV, CL = 95%

[$\tilde{t} \rightarrow c\tilde{\chi}_1^0$, all θ_t , $m_{\tilde{t}} - m_{\tilde{\chi}_1^0} > 10$ GeV]

\tilde{g} — gluino

The limits summarised here refer to the high-mass region ($m_{\tilde{g}} \gtrsim 5$ GeV), and include the effects of cascade decays, evaluated assuming a fixed value of the parameters μ and $\tan\beta$. The limits are weakly sensitive to these parameters over much of parameter space. Limits assume GUT relations between gaugino masses and the gauge coupling,

$$\begin{aligned} \text{Mass } m &> 308 \text{ GeV, CL} = 95\% && [\text{any } m_{\tilde{q}}] \\ \text{Mass } m &> 390 \text{ GeV, CL} = 95\% && [m_{\tilde{q}} = m_{\tilde{g}}] \end{aligned}$$

Technicolor

Searches for a color-octet techni- ρ constrain its mass to be greater than 260 to 480 GeV, depending on allowed decay channels. Similar bounds exist on the color-octet techni- ω .

Quark and Lepton Compositeness, Searches for

Scale Limits Λ for Contact Interactions (the lowest dimensional interactions with four fermions)

If the Lagrangian has the form

$$\pm \frac{g^2}{2\Lambda^2} \bar{\psi}_L \gamma_\mu \psi_L \bar{\psi}_L \gamma^\mu \psi_L$$

(with $g^2/4\pi$ set equal to 1), then we define $\Lambda \equiv \Lambda_{LL}^\pm$. For the full definitions and for other forms, see the Note in the Listings on Searches for Quark and Lepton Compositeness in the full *Review* and the original literature.

$$\begin{aligned} \Lambda_{LL}^+(eeee) &> 8.3 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^-(eeee) &> 10.3 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^+(ee\mu\mu) &> 8.5 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^-(ee\mu\mu) &> 9.5 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^+(ee\tau\tau) &> 7.9 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^-(ee\tau\tau) &> 7.2 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^+(\ell\ell\ell\ell) &> 9.1 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^-(\ell\ell\ell\ell) &> 10.3 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^+(eeuu) &> 23.3 \text{ TeV, CL} = 95\% \\ \Lambda_{LL}^-(eeuu) &> 12.5 \text{ TeV, CL} = 95\% \end{aligned}$$

$$\begin{aligned}
 \Lambda_{LL}^+(eedd) &> 11.1 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^-(eedd) &> 26.4 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^+(eecc) &> 9.4 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^-(eecc) &> 5.6 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^+(eebb) &> 9.4 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^-(eebb) &> 4.9 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^+(\mu\mu qq) &> 2.9 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^-(\mu\mu qq) &> 4.2 \text{ TeV, CL} = 95\% \\
 \Lambda(\ell\nu\ell\nu) &> 3.10 \text{ TeV, CL} = 90\% \\
 \Lambda(e\nu qq) &> 2.81 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^+(qqqq) &> 2.7 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^-(qqqq) &> 2.4 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^+(\nu\nu qq) &> 5.0 \text{ TeV, CL} = 95\% \\
 \Lambda_{LL}^-(\nu\nu qq) &> 5.4 \text{ TeV, CL} = 95\%
 \end{aligned}$$

Excited Leptons

The limits from $\ell^{*+}\ell^{*-}$ do not depend on λ (where λ is the $\ell\ell^*$ transition coupling). The λ -dependent limits assume chiral coupling.

$e^{*\pm}$ — excited electron

$$\begin{aligned}
 \text{Mass } m &> 103.2 \text{ GeV, CL} = 95\% \quad (\text{from } e^*e^*) \\
 \text{Mass } m &> 272 \text{ GeV, CL} = 95\% \quad (\text{from } ee^*) \\
 \text{Mass } m &> 310 \text{ GeV, CL} = 95\% \quad (\text{if } \lambda_\gamma = 1)
 \end{aligned}$$

$\mu^{*\pm}$ — excited muon

$$\begin{aligned}
 \text{Mass } m &> 103.2 \text{ GeV, CL} = 95\% \quad (\text{from } \mu^*\mu^*) \\
 \text{Mass } m &> 221 \text{ GeV, CL} = 95\% \quad (\text{from } \mu\mu^*)
 \end{aligned}$$

$\tau^{*\pm}$ — excited tau

$$\begin{aligned}
 \text{Mass } m &> 103.2 \text{ GeV, CL} = 95\% \quad (\text{from } \tau^*\tau^*) \\
 \text{Mass } m &> 185 \text{ GeV, CL} = 95\% \quad (\text{from } \tau\tau^*)
 \end{aligned}$$

ν^* — excited neutrino

$$\begin{aligned}
 \text{Mass } m &> 102.6 \text{ GeV, CL} = 95\% \quad (\text{from } \nu^*\nu^*) \\
 \text{Mass } m &> 213 \text{ GeV, CL} = 95\% \quad (\text{from } \nu\nu^*)
 \end{aligned}$$

q^* — excited quark

$$\begin{aligned}
 \text{Mass } m &> 45.6 \text{ GeV, CL} = 95\% \quad (\text{from } q^*q^*) \\
 \text{Mass } m &\quad (\text{from } q^*X)
 \end{aligned}$$

Color Sextet and Octet Particles

Color Sextet Quarks (q_6)

Mass $m > 84$ GeV, CL = 95% (Stable q_6)

Color Octet Charged Leptons (ℓ_8)

Mass $m > 86$ GeV, CL = 95% (Stable ℓ_8)

Color Octet Neutrinos (ν_8)

Mass $m > 110$ GeV, CL = 90% ($\nu_8 \rightarrow \nu g$)

Extra Dimensions

Please refer to the Extra Dimensions section of the full *Review* for a discussion of the model-dependence of these bounds, and further constraints.

Constraints on the fundamental gravity scale

$M_H > 1.1$ TeV, CL = 95% (dim-8 operators; $p\bar{p} \rightarrow e^+e^-, \gamma\gamma$)

$M_D > 1.1$ TeV, CL = 95% ($e^+e^- \rightarrow G\gamma$; 2-flat dimensions)

$M_D > 3\text{--}1000$ TeV (astrophys. and cosmology; 2-flat dimensions; limits depend on technique and assumptions)

Constraints on the radius of the extra dimensions, for the case of two-flat dimensions of equal radii

$r < 90\text{--}660$ nm (astrophysics; limits depend on technique and assumptions)

$r < 0.22$ mm, CL = 95% (direct tests of Newton's law; cited in Extra Dimensions review)
